Science Fair Project Guidebook 2:

A Resource for Students, Teachers and Parents

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Introduction

It seems that nothing strikes fear in the hearts of students and parents like these three words: science fair project.

But it doesn't have to be that way. A science fair project is an opportunity to research and learn about things that interest you. And through your studies you will learn how science is basic to everything around us.

You will benefit beyond your improved science knowledge. Science fair projects teach you problem-solving skills, improve your written and oral communication skills and give you the satisfaction of completing a well-done project.

The ideas for projects are endless; you are limited only by your imagination. For example, does dirty dish water affect the growth of plants? Or how does acid rain affect plant growth? Which diapers are the most absorbent? What is the pH of various shampoos? Do different brands of gasoline make a difference in gas mileage?

The first key to a successful science fair project is picking a topic that interests you. The reason is simple: you will be motivated to do a better job on the project and will have fun doing it. And remember, a good science fair project doesn't have to be complicated. It is important that you understand your project and that you have explored the scientific and technical issues related to your project.

The second key is careful planning. After discussing your project with your teacher and getting approval for your idea, allow yourself plenty of time for research, experiments, observation and analysis. In other words, don't wait until the last minute. Projects take time.

Ask questions about your project, but do the work yourself. If you do the work yourself, you will get a much better understanding of why things do and do not work as expected.

Finally, don't get upset if your experiments prove your hypothesis incorrect. Throughout history, some of the most important experiments were those that didn't prove the original hypothesis.

On the following pages are basic ingredients for a science fair project and tips for a great display as well as suggestions for making a great presentation. Best of all, there are 10 science fair projects complete with easy-to-understand instructions. In addition, there are different subjects, including air, energy, water and recycling.

By performing one of the science projects in this guidebook, you will gain a better understanding of science, and who knows, maybe you'll find a new way to protect the environment.

Be careful doing your project. Give yourself plenty of time. Don't be afraid of making mistakes. Enjoy your work and have fun. But most of all - learn. Good luck.

What is a Science Fair Project?

A science fair project is an investigation of a question that involves research, planning and application of the scientific method to find the answer.

The Scientific Method

The *scientific method* is a tool that scientists use to find answers to questions. The tool involves the following steps: doing research, identifying a problem, stating a hypothesis, conducting project experimentation and reaching a conclusion.

Research

Your *research* begins when you select your project topic. Once you have chosen your topic, you'll begin your project research. HERE'S A TIP: Choose a catchy title. Make it specific. Usually, it's best for the title to be a question or something like this:

- The Effects of...
- The Study of...
- An Investigation of...
- A Comparative Study of...
- The Observation of...

Tips on How to Choose a Science Fair Project

- List your favorite activities and subjects. Now, select a project from one of those areas.
- What are some of the materials you could use with your experiment? Are the materials available at your home? You may want to select materials that are inexpensive and easy to find.
- Your school library and local public library are good places to go for more information to complete your science fair project.

Problem

The *problem* is the question to be answered.

Hypothesis

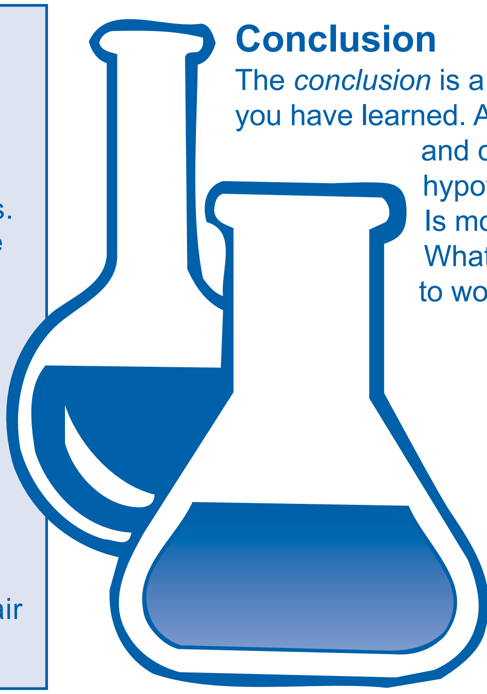
The *hypothesis* is simply your best guess as to what will happen.

Project Experimentation

Project experimentation means testing your hypothesis. This includes more research, designing and planning for experimentation and testing. Test your hypothesis carefully by experimenting. Record everything you do. Make observations and record the results. Make charts and graphs or take pictures so others can understand what you have done.

Variables

Things that can affect your experiment are called *variables*. The *independent variable* is the variable you purposely change. The *dependent variable* is the variable you are observing that changes in response to the independent variable. The variables that are not changed are called *controlled variables*.



Conclusion

The *conclusion* is a summary of what you have learned. Analyze your data and decide if your hypothesis was correct. Is more work needed? What else would you do to work on this problem?

Getting Started...

Choose a Topic

Again, don't wait until the last minute to start your project. Choose a topic that is interesting to you. If you need an idea, begin by looking through newspapers and magazines, visiting the library, watching the news and educational shows and exploring the Internet.

Ask your parents, teachers and friends. Visit a museum or zoo. Make sure the topic you choose is one you can do by yourself. Can you get all the necessary equipment and supplies?

State the Purpose

What do you want to discover?

Make a Hypothesis

What do you think will happen based on your knowledge?

Decide on a Procedure

What do you need to do to find the answer? What steps do you need to take? What materials will you need? What background information will you need? Gather information about your topic. Record all of your information and sources in a logbook.

Experiment

Test your hypothesis carefully by experimenting. Record everything you do. Make observations and record the results. Draw pictures and make graphs so that another person can understand what you have done.

Draw Conclusions

Analyze your data and decide if your hypothesis was correct. Is more work needed? What else would you do to work on this problem? Give a one sentence conclusion to your experiment.

Tips for Building a Great Display

You have worked hard on your project so it is important to display it well. The keys to a good display are simplicity, neatness and clarity. Do not attempt something elaborate.

You should have a three-fold standing display and a logbook. If you have an interesting piece of equipment, you may want to also display it. Remember, at presentation time there should be no food, no live animals or plants, no chemicals, nothing hot or electrical and nothing valuable.

A good display takes as much planning as the project. You will need the following:

- A white, three-fold cardboard backboard (colored backgrounds sometimes work, but simple is best);
- Bright colored letters for your title and categories (computer-generated or adhesive lettering);
- Colored construction paper behind your neatly typed pages of explanation to set them off from the backboard, and neat charts and graphs;
- At least one drawing or photograph; and
- A logbook recording how you conducted your experiment.

Your display should contain the following categories:

- Title
- Purpose statement
- Abstract (required for high-level competition)
- Hypothesis
- Procedure
- Data/results charts, graphs, analysis
- Conclusion

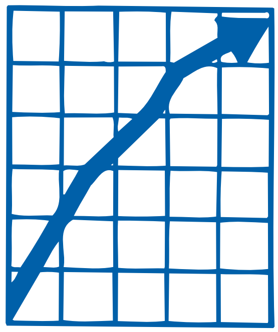
Your logbook should contain the following:

- Title page
- Table of contents
- Purpose statement
- Abstract
- Hypothesis
- Materials
- Procedure
- Data
- Charts, graphs, other analyses of your data
- Conclusion
- Background information (listed in correct bibliographic form)
- Acknowledgments (did a parent, teacher, librarian help you?)

More to Getting Started...

Other Helpful Hints

- Color coordinate your display. Make it eye-catching.
- Make it so that the judge can get some good information just by glancing at your display (simple and clear).



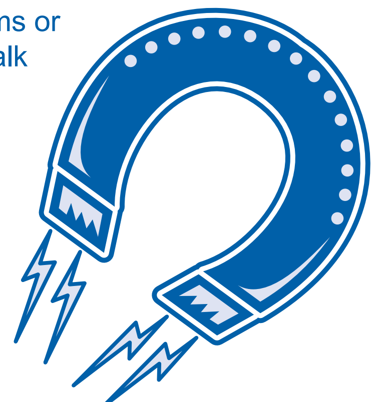
- Have magazine articles, pamphlets, etc., to display along with your logbook. Attract people to your display.
- Triple-check your spelling (nothing is more of a turn-off than poor spelling on a display).
- Make sure everything is neat (no sloppy erasures, crossed-out words, graphs falling off).

If You Have to Answer Questions or Make a Presentation...

Frequently, you'll have to answer questions about your science fair project to science fair judges, parents and teachers. And sometimes, you may have to make a classroom presentation.

Here are some helpful hints to prepare:

- Introduce yourself and tell your age and grade.
- Give the title of your project.
- Explain the purpose of your project.
- How did you get interested in this topic?
- Explain your hypothesis and procedure.
- Show your results. Show the judge your logbook and all charts and graphs of your results.
- List your conclusions. Explain how you interpreted your data.
- If you had problems or made mistakes, talk about them. Mistakes can be valuable data in science.



- Tell the judges what you would do next to continue working on this topic. If you were to change or redo this project, how would you go about it?
- Ask the judges if they have any questions.
- Thank the judges for their attention.
- Smile, relax, stand straight and speak loudly.
- Be confident. You've done the work, done it well and it will show!

DID YOU KNOW? The first edition of the "Science Fair Project Guidebook" is available online at **www.scdhec.net/recycle** (click on "Energy 2 Learn" under Education Programs on the menu). The guidebook contains 10 detailed, ready-to-go energy experiments.

The Experiments

Air Quality

Project #1: Don't Take a Lichen for Air Pollution

BACKGROUND:

Plants called lichens are sensitive to air pollution, especially the air's acidity. So, you can use their presence or absence as an indicator of air quality. They are actually two types of plants, algae and fungi, growing so closely together that they look like one single organism. They are often considered symbiotic organisms - mutually beneficial to each other. Lichen fungi cannot live without their algae partners, while most of the algae can live by themselves. Lichens often grow in locations where most other plants cannot - bare rocks, tree trunks, bare soil. In some of these locations they play an important role helping soil formation. By interacting with the bare rocks to help break them down chemically and by trapping dust and organic matter from the air, lichens often start to create and enrich soil where other plants can eventually grow.


Leaf-like Lichen


Crusty Lichen

Reprinted with permission from *A&WMA's Environmental Resource Guide (ERG) – Air Quality,* 6-8, 1991; Air & Waste Management Association, Pittsburgh, PA 15222.

Every natural habitat from deserts to rain forests has lichens. They are able to survive extreme conditions of heat, cold and drought. However, few species of lichens can survive air pollution, particularly acid air pollution. Lichens come in a variety of sizes, shapes, colors and textures. Lichens are often divided into three classifications - crusty, leaflike or shrubby. Crusty lichens usually grow flat on rocks and tree trunks and may be embedded in these surfaces. Crusty rock lichens are colorful and range from oranges and yellows to greens, browns, grays and blacks.

Leaf-like lichens have lobed surfaces that are only partially attached to other surfaces. Shrubby lichens are branched and either stand upright or hang from other surfaces. Leaf-like and shrubby lichens are usually some shade of green. Lichens are often confused with moss, but real mosses are tiny plants with leaves and stems. Scientists study both the type of lichens present and the size of the lichens. Shrubby and leaf-like lichens can only survive in clean air.

Lichens are relatively rare in large cities, and in areas of very heavy air pollution, there are no lichens of any type. The size of the lichens present is also important. Larger individual lichens generally mean better air quality. In 1971, an air quality map of the British Isles was made based on an evaluation of lichen presence and growth. Lichens are also valuable for evaluating air quality in another way. Lichens accumulate metals and other elements from rainwater and dust. By analyzing lichens that live near emission sources for chemicals which indicate pollution, scientists can determine how far the pollution has spread.


Shrubby Lichen

MATERIALS:

- Small Marking Flags
- Masking Tape
- Permanent Marker
- Lichen Grid
- Pencil
- Graph Paper
- Clipboard
- Camera

PREPARATION:

1. Know the background information.
2. Make sure you have all of the materials.
3. Identify the location where the lichen are present.
4. Draw a map of the area.
5. Mark each flag to be able to identify it.

PROCEDURE:

1. Place the marked flags near the lichen.
2. Draw the location of the flags on the map.
3. Collect some of the lichen and trace them onto the grid.
4. Measure the lichen and record the size and type onto the same grid sheet.
5. Enter all of the data onto a master map (location, type of lichen and size).

RESULTS:

1. What kinds of lichens are found at the study site? Use the sheet "Lichens as Pollution Indicators" to assess the air quality using the lichen type.
2. What size are the lichens? Use the chart "Measuring Air Quality with Lichens," to assess air quality based on size.
3. Are the results the same using both methods?
4. Look at the site map. Describe where you found the biggest and smallest lichens and why.
5. Do you think air quality is affecting lichens at this site? Why or why not?

To learn more about the air in South Carolina, visit DHEC's Bureau of Air Quality Web site at **www.scdhec.net/baq**.

Lichens as Pollution Indicators

Plants called lichens are sensitive to air pollution, especially the air's acidity. So, you can use their presence or absence to see how clean the air is. Shrubby and leafy lichens only survive in clean air. In the most polluted areas there are none at all. Look for lichens on walls, stones and trees, and use this scale to rate the air quality.

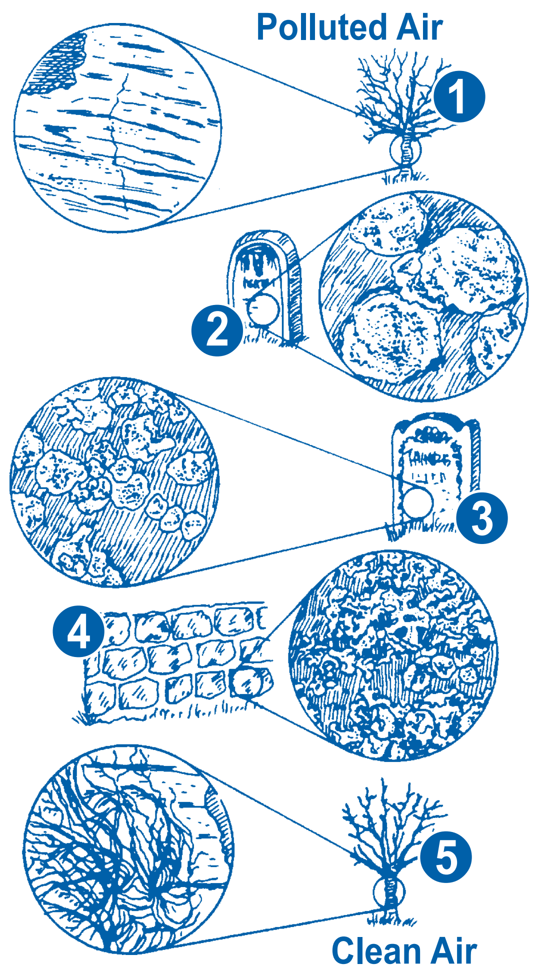
NOTE: Different lichen types can be found in the same area. To use this scale, decide which lichen type is most common in the study area.

SCALE

POLLUTED AIR

1. No lichens (possibly green algae)
2. Grey-green crusty lichens (tombstones)
3. Orange crusty lichens (tombstones)
4. Leafy lichens (walls and trees)
5. Shrubby lichens (trees)

CLEAN AIR



MEASURING AIR QUALITY USING LICHEN SIZE

SIZE (square centimeters)	**AIR QUALITY**
10 - 12	Excellent
7 - 9	Good
4 - 6	Fair
0 - 3	Poor

The Lichen Grid

Project #2: Stick 'Em Up

BACKGROUND:

The air around us is invisible. It is made up of gases that cannot be seen. Many major air pollutants are also invisible gases. In some areas of the country, these air pollutants can build to levels where they can be seen. For example, in some California cities, smoky, yellowish clouds of primarily car exhaust build up to create **smog**.

Other easily visible air pollutants, called **particulate matter**, are made up of tiny particles of solids or droplets of liquids. Some of these particulates are naturally occurring and may pose less of a problem to human health than do man-made particulates. Some of the natural particulates include pollen, wind-blown dust or volcanic ash. Man-made particulates are generated by coal and oil-fired power plants, manufacturing plants, automobile and diesel fuels, and fireplaces and wood-burning stoves among others.

These **airborne** particulates, or particles carried through the air, can be harmful to plants, animals and humans. Buildings and statues can be discolored. Analysis and measurement of air pollutants can be done by various means, depending on the chemical and physical characteristics of the pollutant. Particulate matter measurement uses gravimetric principles, which refers to measurement by weighing. Particles are trapped or collected on filters, and the filters are weighed to determine the volume of the pollutant. The weight of the filter with the collected pollutant minus the weight of a clean filter gives the amount of particulate matter in a given volume of air.

PREPARATION:

1. Follow the directions and make the Stick 'Em Up Collectors (or create your own).
2. Weigh the collectors before they are used.
3. Select different sites to hang the Stick 'Em Up Collectors. On each collector, record name, location, date and time it is hung or set in its location. Site selections may include inside your room, your kitchen, the garage, near the pets sleeping quarters, in the gym at school, bathrooms, outside near a tree, near the parking lot, on the recess field, etc. These should be placed where they can hang freely, or set somewhere not touching other objects and where they will not be touched by other people. Be sure to let the custodial staff and your family know about this, too.
4. Draw a map of the area including the location of each collector (optional).

PROCEDURE:

1. Record the information on a chart including the "clean" weight of the collector, and the location.
2. Place the collectors in their locations and leave them for at least eight days.
3. Take up the collectors and analyze them by weighing them and observing them through a microscope or magnifying glass.
4. Take pictures of some of the collectors in their location (optional).

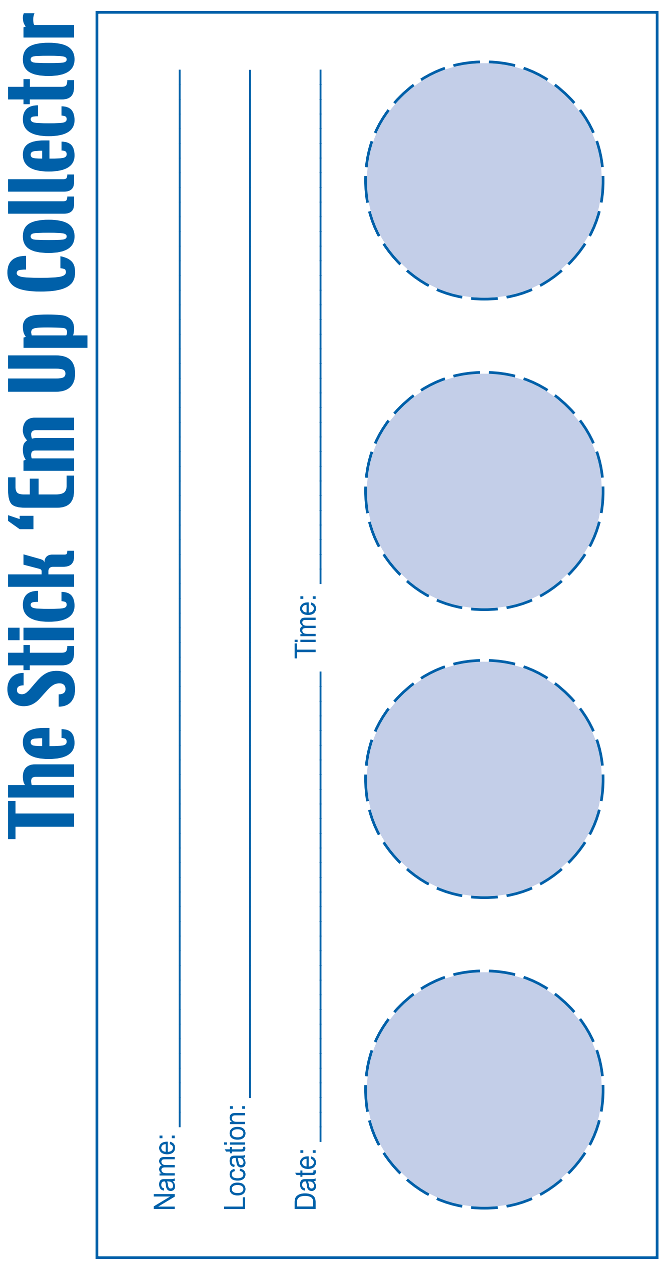
MATERIALS:

- Stick 'Em Up Collectors
- Scissors
- Clear Tape
- String
- Hole Punch
- Magnifying Glass or Microscope
- Marker
- Scales (in milligrams)
- Clipboard
- Graph Paper
- Pencil
- Camera (optional)

RESULTS:

1. What is the weight of the collectors after the eight days? (compare to the weight before they were used)
2. What did you observe under the microscope or magnifying glass?
3. Did you have more particulate matter inside or outside? (compare the results)

REMEMBER: Always chart the information you collect throughout the project.



CONCLUSION:

1. Can we see air pollution? How do we know that air pollution exists?
2. Give examples of visible air pollution.
3. Discuss the concept of particulate matter.
4. Why do you think one location may have more particulate matter than another? What is in that area that may be the cause?
5. List some sources of air pollution, both visible and invisible. Can a single source provide both visible and invisible air pollution?

EXTENSION ACTIVITY:

Make a traffic survey. Pick a location where you can observe a busy intersection from a safe distance. Separately record the number of trucks, cars, buses, vans and taxi cabs that pass through that intersection in a given hour. Try this over several days at different times of the day.

- **Ask:** What factors influence volume of traffic? (*locations of highways, number of people in the community, shopping centers, businesses, special events, etc.)*
- **Ask:** Did you see evidence of air pollution? *(smells, smoke, wilted plants struggling to survive etc.)*
- **Ask:** Do you think this is a problem? Why or why not? If so, what do you think should be done to correct it?

STICK 'EM UP COLLECTOR:

1. Copy the Stick 'Em Up sheet and make your particulate matter collector (left).
2. Cut out the four holes in the strip as marked. Using the hole punch, make a hole in the top and tie the string into a loop.
3. Cover one side of the strip with clear tape so that the holes are covered on one side. DO NOT TOUCH THE STICKY SIDE OF THE TAPE THAT IS SHOWING THROUGH THE HOLES.

Project #3: Comparing Light Bulbs

BACKGROUND:

There are many types of light bulbs available these days. Two that are used primarily at home are incandescent and fluorescent light bulbs. Which kind do you think produces the most heat? Do you think they give off the same kind of light?

MATERIALS:

- One incandescent bulb
- One fluorescent bulb (NOTE: The bulbs should produce equivalent lumens.)
- Thermometer
- Lamp

PROCEDURE:

1. Have an adult place the fluorescent bulb in the lamp and turn it on. Observe the light that is produced.
2. Hold a thermometer six inches above the bulb for one minute and record the temperature. Turn off the lamp and let the bulb cool.
3. Have an adult remove the fluorescent bulb, place the incandescent bulb in the lamp and turn it on. Observe the light that is produced.
4. Hold a thermometer six inches above the bulb for one minute and record the temperature.

EXTENSION QUESTIONS:

1. Could you tell any difference in the kind of light the two bulbs produced?
2. Did one bulb produce more heat than the other?
3. Which bulb is more energy efficient?

Project #4: Energy for Life

BACKGROUND:

Plants need several things to survive and grow. They need water, nutrients from the soil and carbon dioxide from animals. But what about sunlight?

MATERIALS:

- Two similar plants
- A brown paper bag
- Water

PROCEDURE:

1. Place two plants in a sunny place.
2. Cover one plant with a brown paper bag.
3. Give both plants the same amount of water.
4. Observe the plants for two weeks.

EXTENSION QUESTIONS:

1. Which plant looks healthier after two weeks?
2. How did the covered plant appear different from the uncovered one?
3. Did the covered plant need sunlight?

Project #5: A Salty Sea

BACKGROUND:

Oceans cover about 71 percent of the earth's surface. Oceans contain salt water, however there are some parts of the world where the water is saltier than in other locations. The sun over the ocean causes the water to evaporate. Salt, however, does not evaporate and is left behind, causing the remaining saltwater to be even saltier.

MATERIALS:

- Table salt
- Tea kettle
- Water
- Hot plate
- Glass or plastic plate
- World map

PROCEDURE:

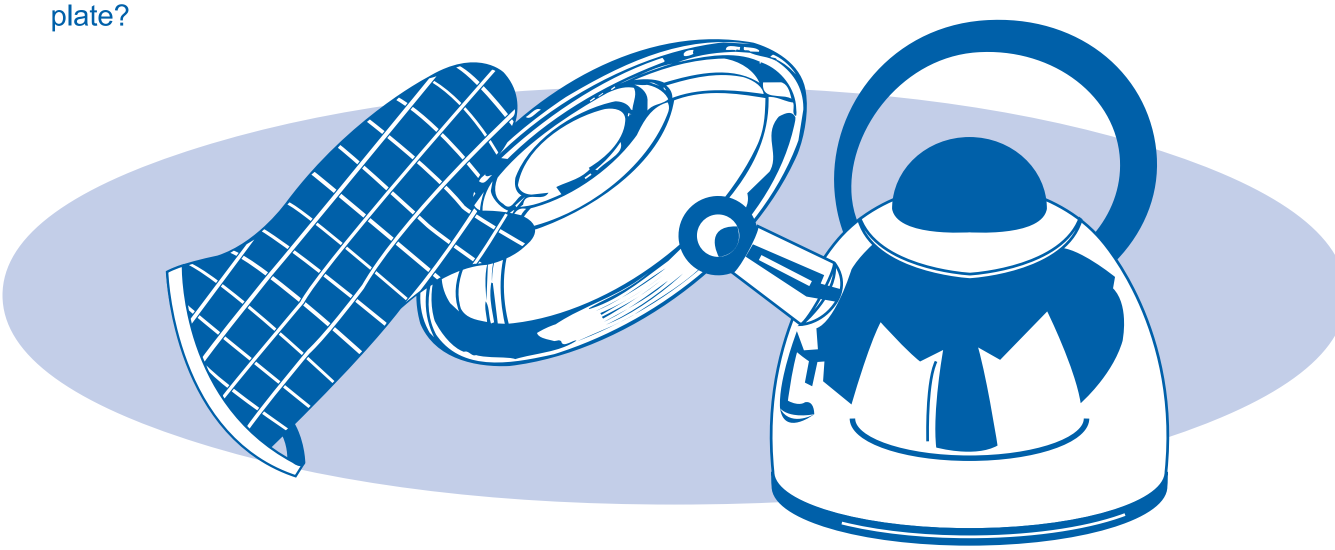
1. Combine two cups of water with table salt (2 tablespoons) and place in the tea kettle. Taste a drop of this mixture. With the help of an adult, bring the water in the kettle to a boil.

2. Have the adult hold the plate over the escaping steam and allow a few drops to accumulate. Be careful not to come in contact with the steam - it can be very hot. Pull the plate away and allow the drops to cool, then taste a drop. Is it as salty as the original mixture?

3. Boil the remaining water left in the kettle for five minutes. Allow the water to completely cool and taste it again. Does this taste saltier or less salty than the original mixture? Does it taste saltier or less salty than the drops on the plate?

EXTENSION QUESTIONS:

1. Look at the map of the world. Where are the warmest oceans? The coolest?
2. When water is heated, what happens?
3. What does evaporation mean?
4. Which seas and ocean might be the saltiest? Why?



Project #6: Soap Box Opera

BACKGROUND:

Usually, it is more economical to buy larger rather than smaller sizes of products. Purchasing larger quantities is known as “buying in bulk.” For example, a five-ounce box might only cost $5, making the cost $1 per ounce whereas a 10-ounce box might cost $8 or 80 cents per ounce. Buying in bulk might have advantages other than cost savings.

Examine the ratio of carton material to the product quantity. Does buying in larger quantities also require less packaging material per unit measure of the product? Could people lessen their impact on the environment by buying in bulk?

MATERIALS:

- Different sized laundry detergent boxes
- A scale
- A calculator

PREPARATION:

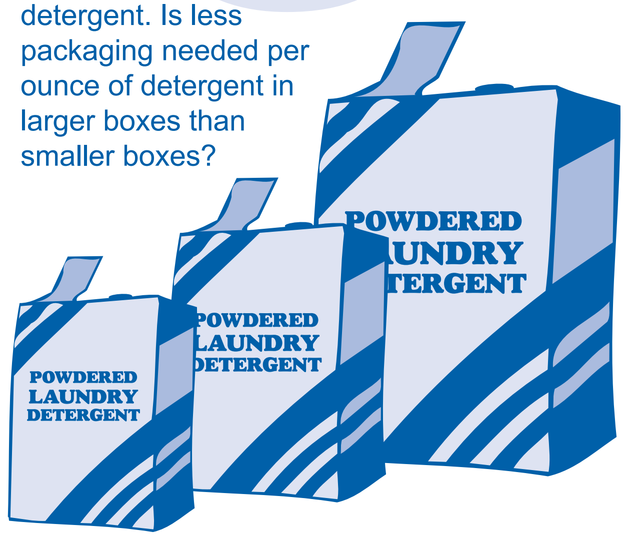
Purchase several different-sized laundry detergent boxes. Pour the contents of each into separate containers – one container for each box.

PROCEDURE:

1. Before pouring the detergent into the containers, weigh the containers while they are empty and record the weights of the containers. Weigh the detergent in the separate containers and record the numbers. Take the total weight and subtract the weight of the container. This number will be the weight of just the detergent.

2. Weigh the empty boxes that the detergent came in. Record these numbers.

3. Divide the weight of the empty box by the weight of the detergent. This will tell how much packaging is needed for the amount of detergent. Is less packaging needed per ounce of detergent in larger boxes than smaller boxes?



Weight of Container	Weight of Container & Detergent	Weight of Container & Detergent - Weight of Container = Weight of Detergent	Weight of Detergent Box	Weight of Detergent Box ÷ Weight of Detergent

Project #7: Natural or Man-made Fibers

BACKGROUND:

Some fibers are made from natural materials like cotton, while others are made from man-made or "synthetic" materials like polyester. Which type of fiber do you think will decompose faster – natural fibers or synthetic fibers?

MATERIALS:

- A 100% cotton T-shirt
- An old nylon stocking
- An old wool sock
- An old acrylic or polyester sweater
- A plot of soil
- Water
- A glass jar with lid

PROCEDURE:

1. Cut three four-inch squares from each material.
2. Bury one square of each material, making sure you mark the spot where they are buried. Put a second square of each material in a jar, fill it with water and put a lid on it. Place the jar inside in a sunny place. Place the third squares in a dark place where they will not be disturbed.
3. After one month, remove the samples from the ground, jar and dark place. Examine the squares and record your observations.

EXTENSION QUESTIONS:

1. Which fibers deteriorated the most?
2. Which environment made the materials deteriorate more quickly?
3. Can you find out why?

Project #8: Test Your Strength

BACKGROUND:

Some people question whether products made from recycled materials can perform their job as well as products made from entirely new materials. Plastic, paper products, aluminum cans and some clothing are all commonly available with both new and recycled content.

MATERIALS:

You will need products made from "virgin" (new) materials and recycled content materials such as writing paper, pencils, folders and clothing.

PREPARATION:

Purchase similar items made from recycled content and "virgin" (new) materials.

PROCEDURE:

Compare the strength and performance of the "virgin" (new) product to ones made with different percentages of recycled content.

Product	Tests Performed	Performance

EXTENSION QUESTIONS:

1. Does manufacturing a product with recycled materials alter its performance?
2. Which materials were stronger or more durable?
3. In what ways did the recycled materials perform better or worse than the products made from new materials?

Project #9: The Water Table

OBJECTIVE:

In this activity, you will create a model of the water table and conduct an experiment to see how water is stored in the ground and how water runoff and pollution move through soil.

BACKGROUND:

Precipitation falls into water or on land where it "runs off" of hard, or impervious, surfaces such as rock or concrete, or infiltrates soft, or pervious, surfaces such as soil or sand. If water moves downward, it can replenish water contained in the underground rock and sediment. This supply of water is referred to as *"groundwater."*

Groundwater is water that has percolated into the ground and is held under the surface. Rain seeps through the top layers easily. The earth near the surface is loaded with tiny air spaces. Even rocks have cracks and pores through which water can find its way. But when water reaches clay or impervious rock, it will not sink any farther.

As more water seeps or percolates into the ground, it begins to collect above the bedrock or dense soil. When the ground has as much water as it can hold, it is saturated. Water that seeps into the ground fills the tiny crevices and the water level rises toward the surface as the spaces in the ground fill up. The uppermost level is called the *water table.*

MATERIALS:

Refer to the illustration of the water table model.

- Wide-mouth glass jar (or a two-liter plastic soda bottle with the top cut off)
- Beaker, measuring cup or any cup for pouring water
- Crayon (dark color works best to mark on plastic) or permanent marker
- Mixture of sand and gravel (several cups)
- Water (several cups)

The area of dry ground above the water table is called the *zone of aeration*. After heavy rains, the table is nearer the surface, and in dry weather it drops again.

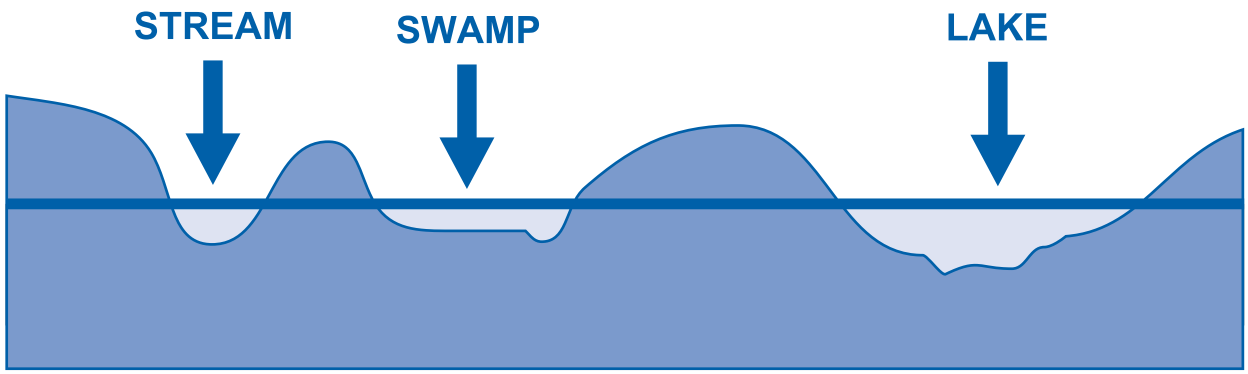
PREPARATION:

1. Fill a clear container (soda bottle or jar) three-fourths full of sand and gravel mix. Next, pour water down the side of the jar until the water level rises about half way up the side of the jar. This water level should represent the level of the water table. Use a crayon or marker to mark the present level. Point out that if more water is added, the water table will rise.

2. Using your crayon or marker, press down on the sand in one spot down to the water table to show that wherever the land surface dips below the water table, groundwater flows out

to the surface. This forms springs, swamps or lakes. Explain that during dry weather periods, the water table level goes down and some streams and swamps may dry up as well. You may want to draw the water table illustration below on the board as an example.

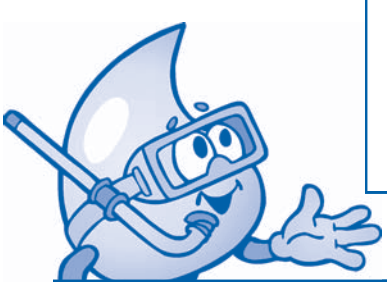
Water Table



EXTENSION ACTIVITY:

The following activity will demonstrate how water moves through different types of soil. You will also measure volume accurately, identify three types of soil by texture and make visual observations about water movement through the soil.

NOTE: This activity should be preceded by a discussion of types of soils, and how water is absorbed into the soil and moves, with time, around the soil particles.

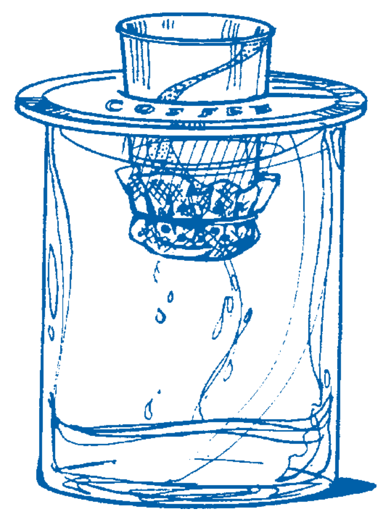


MATERIALS:

- Three large polystyrene cups
- Three plastic coffee can lids
- Three squares of cheesecloth
- Rubber bands
- Water
- Thumbtack
- Watch or clock
- Sand
- Clay
- Gravel
- Pencil
- Four 250-ml beakers or cut-off soda bottles
- Scissors
- Measuring cup

PROCEDURE:

1. Using a thumbtack, punch several holes in the bottom and around the lower part of each cup.
2. Place a square of cheesecloth over the bottom of each cup so it covers all the holes, and secure it tightly with a rubber band.



3. Using scissors, cut a hole in the plastic coffee can lid so that the cup just fits inside. Place each cup in a lid, and place each lid over a beaker. (See the illustration for the demonstration set up.)

   Label the cups A, B and C.

4. Fill Cup A half full of dry sand, Cup B half full of clay, and Cup C half full of a mixture of sand, gravel and clay.

5. Make a chart similar to the one below for recording your observations.

6. Pour 100 ml of water into the middle or center of each cup. Record the time when the water was first poured into each cup.

7. Record the time when the water first drips from each cup. Note the appearance of the water.

8. Allow the water to drip for 25 minutes. At the end of this time, remove the cups from the beakers. Measure and record the amount of water in each beaker.

QUESTIONS:

1. Which soil sample is the most permeable?

2. Which soil is the least permeable?

3. How does the addition of gravel affect the permeability of clay?

4. How does soil type affect the movement of groundwater?

5. Can soil protect groundwater? Which one? How?

CUP	TIME WATER IN	TIME WATER OUT	OBSERVATIONS
A			
B			
C			

Project #10: Taking the Swamp Out of Swamp Water

OBJECTIVE:

This project demonstrates the procedures that municipal water plants use to purify water for drinking.

BACKGROUND:

Water in lakes, rivers and swamps often contains impurities that make it look and smell bad; it may also contain bacteria and other microbiological organisms that can cause disease. In most places, surface water should not be drunk until it has been cleaned. This project shows how water treatment plants turn polluted water into drinking water.

This project illustrates the four basic processes involved in purifying water for human consumption. Water treatment plants typically clean water by taking it through the following processes: (1) *aeration;* (2) *coagulation* and *sedimentation;* (3) *filtration;* and (4) *disinfection.* Demonstration projects for the first four processes are included below.

PROCEDURE:

1. Pour about 1.5 liters (L) of "swamp water" into a two-liter bottle. Have your audience describe the appearance and smell of the water.

2. Place the cap on the bottle and shake the water vigorously for 30 seconds. Continue the aeration process by pouring the water into either one of the cut-off bottles, then pouring the water back and forth between the cut-off bottles 10 times.

   Describe any changes you observe. Pour the aerated water into a bottle with its top cut off. *Aeration* is the addition of air to water. It

MATERIALS:

- **Five liters of "swamp water"** (use muddy water from a pond or creek or "custom mixed" swamp water made by adding a handful of dirt or mud to each liter of water)
- **One two-liter plastic soft drink bottle** with its cap (or cork that fits tightly into the neck)
- **Two two-liter plastic soft drink bottles** - one bottle with the top removed and one bottle with the bottom removed
- **One 1.5-liter (or larger) beaker** or another soft drink bottle bottom
- **20 grams (g) or two tablespoons of alum** (potassium aluminum sulfate; available in drug stores or spice aisle of most supermarkets)
- **Fine sand** (about 800 milliliters (ml) in volume)
- **Coarse sand** (about 800 ml in volume)
- **Small pebbles** (about 400 ml in volume) Washed natural color aquarium rocks will work.
- **One 500 ml (or larger) beaker or jar**
- **One coffee filter** or five centimeters (cm) X five cm piece of flexible nylon or fine mesh screen
- **One rubber band**
- **One tablespoon**
- **A clock** with a second hand (or a stopwatch)

allows gases trapped in the water to escape and adds oxygen to the water.

3. With the tablespoon, add 20 g of alum crystals (potassium aluminum sulfate) to the swamp water. Slowly stir the mixture for five minutes. *Coagulation* is the process by which dirt and other suspended solid particles are chemically "stuck together" so that they can be removed from water.

4. Allow the water to stand undisturbed in the cylinder. Observe the water at five-minute intervals for a total of 20 minutes and write your observations with respect to changes in the water's appearance. *Sedimentation* is the process that occurs when gravity pulls the particles of floc (clumps of alum and sediment) to the bottom of the cylinder.

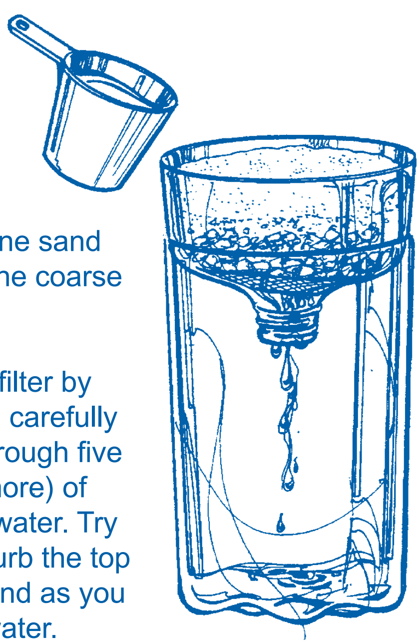
5. Construct a filter from the bottle with its bottom cut off as follows:

    a. Attach the coffee filter to the outside neck of the bottle with a rubber band. Turn the bottle upside down and pour a layer of pebbles into the bottle - the filter will prevent the pebbles from falling out of the neck.

    b. Pour the coarse sand on top of the pebbles.

    c. Pour the fine sand on top of the coarse sand.

    d. Clean the filter by slowly and carefully pouring through five liters (or more) of clean tap water. Try not to disturb the top layer of sand as you pour the water.



6. After a large amount of sediment has settled on the bottom of the bottle of swamp water, carefully - without disturbing the sediment - pour the top two-thirds of the swamp water through the filter. Collect the filtered water in the beaker. Pour the remaining (one-third bottle) of swamp water back into the collection container. Compare the treated and untreated water. Has the treatment changed the appearance and smell of the water? *Filtration* through a sand and pebble filter removes most of the impurities remaining in water after coagulation and sedimentation have taken place.

ATTENTION!

Advise your audience that the final step at the treatment plant is to add disinfectants to the water to purify it (that is to kill any organisms that may be harmful). Because the disinfectants are caustic and must be handled carefully, it is not presented in this experiment. The water that was just filtered is therefore unfit to drink and can cause adverse effects. IT IS NOT SAFE TO DRINK!

EXTENSION ACTIVITIES:

1. Plan a field trip to a local water treatment plant. Find out how (or whether) the plant removes bacteria, lead or other heavy metals, such as nitrates, sulfides or calcium from the water.

2. Contact a state or local agency that tests water for contaminants. Have the agency test samples of tap water and the swamp water that you treated.

3. Add garlic powder to the swamp water and filter it out using deodorizing charcoal and filter paper (coffee filters).

‘Energy 2 Learn’

“The Science Fair Project Guidebook 2: A Resource for Students, Teachers and Parents” is part of “Energy 2 Learn,” a comprehensive energy education program for South Carolina’s students and teachers. “Energy 2 Learn” includes:

- **“Action for a cleaner tomorrow: A South Carolina Environmental Curriculum Supplement:”** This kindergarten through 12th grade curriculum supplement has air, recycling, water and energy lessons that provide not only a global and national perspective on energy, but South Carolina-specific information as well. Teachers can receive a copy or CD-ROM of “Action” following a FREE three-hour workshop.

- **Palmetto Energy Awards Program:** PEAP is a special program for K-6 students designed to help them learn about energy and how it affects their everyday lives. By completing teacher-approved projects on energy conservation and energy sources, students will earn points toward winning different awards. PEAP can be done in individual classrooms or the entire school.

- **South Carolina/National Energy Education Development Project:** The National Energy Education Development Project is a nationally recognized energy education program dedicated to developing innovative educational materials and training programs for teachers and students. NEED materials and training programs are designed to provide comprehensive, objective information on the scientific concepts of energy and the major energy sources.

- **“Energy 2 Learn” - The Summer Workshop:** Every summer a workshop is offered to teachers statewide to provide the latest information and educational materials on energy and other environmental issues, including air, recycling and water. Admission is free, but spaces are limited.

- **“The Energy Factbook: A Resource for South Carolina:”** The “Factbook” provides an overview of energy with chapters on energy basics, fossil fuels, nuclear energy, electricity, solar energy, energy conservation and energy efficiency. The “Factbook” is available at no cost to teachers and students.

All program materials are available at no cost to teachers, schools or students. Teachers are welcomed and encouraged to use any or all of the programs offered. “Energy 2 Learn” offers balanced, objective and multi-sided information and materials, providing South Carolina’s teachers and students with one of the nation’s most comprehensive energy education programs. **“Energy 2 Learn” is provided by a cooperative education partnership between the S.C. Energy Office and the S.C. Department of Health and Environmental Control’s Office of Solid Waste Reduction and Recycling.**

Glossary

Abstract – A brief summary of the experiment.

Conclusion – The summary of the results of the project experimentation including a statement of how the results relate to the hypothesis.

Hypothesis – An idea about a solution to a problem that is based on knowledge and research.

Project experimentation – Doing experiments designed to test the hypothesis.

Problem – A scientific question to be solved.

Procedure – The process of deciding what needs to be done to find the answer to the problem. For example, what steps need to be taken, what material are needed.

Research – The process of collecting information.

Scientific method – The tool that scientists use to answer questions. The process of thinking through solutions to a problem and testing possibilities to find the solution. The scientific method has the following steps: research; identifying the problem; hypothesis; project experimentation; and reaching a conclusion.

Variable – Something that has an effect on an experiment. An **independent variable** is a manipulated variable in an experiment that causes a change in the **dependent variable**. For example, different golf clubs. A dependent variable is the variable being observed in an experiment that changes in response to the independent variable. The distance a golf ball travels after being hit by a golf club.

Ideas for More Projects

ENERGY

- Should you take a shower or a bath to save energy?
- Which type of material makes the best insulation?

HEALTH

- Is there a relationship between eating breakfast and performance at school?
- Which fruit drinks have the best nutrition?
- Which brand of cereal has the most raisins?
- What is the pH of various shampoos, lotions and sunscreen products?

PLANTS AND GARDENING

- What type of soil is best for water retention?
- Can potatoes be grown without soil?
- Does the type of water affect the growth of plants?

RECYCLING AND WASTE MANAGEMENT

- What happens to newspaper in a landfill?
- What types of materials decompose the fastest or slowest?
- What is the environmental impact of some household chemicals and/or pesticides?

WATER

- What is in drinking water?
- Does the amount of water affect the size of the wave?
- Where is the current of a stream fastest?
- How does depth affect water pressure?
- What makes a good filter for drinking water?

WEATHER

- How can we prevent the weathering of sidewalks and driveways?
- Does soil in South Carolina show the effects of acid rain?
- What causes dew?

OTHER

- Which diaper is the most absorbent?
- How do magnets affect tape recordings?
- Are home-made cleaners as effective as store-bought ones?
- Do different brands of gasoline make a difference in gas mileage?
- Does color affect the behavior of people?

Weights & Measures

CUSTOMARY U.S. MEASURES AND EQUIVALENTS

LENGTH

1 inch (in)		= 2.54 cm
1 foot (ft)	= 12 in	= .3048 m
1 yard (yd)	= 3 ft	= .9144 m
1 mile (mi)	= 1760 yd	= 1.6093 km
1 nautical mile	= 1.152 mi	= 1.853 km

AREA

1 square inch (in^2)		= 6.4516 cm^2
1 square foot (ft^2)	= 144 in^2	= .093 m^2
1 square yard (yd^2)	= 9 ft^2	= .8361 m^2
1 acre	= 4840 yd^2	= 4046.87 m^2
1 square mile (mi^2)	= 640 acres	= 2.59 km^2

WEIGHT

1 ounce (oz)	= 437.5 grains	= 28.35 g
1 pound (lb)	= 16 oz	= .4536 kg
1 short ton	= 2000 lb	= .9072 t
1 long ton	= 2240 lb	= 1.0161 t

VOLUME

1 cubic inch (in^3)		= 16.387 cm^3
1 cubic foot (ft^3)	= 1728 in^3	= .028 m^3
1 cubic yard (yd^3)	= 27 ft^3	= .7646 m^3
1 fluid ounce (fl oz)		= 2,957 cL
1 liquid pint (pt)	= 16 fl oz	= .4732 L
1 liquid quart (qt)	= 2 pt	= .946 L
1 gallon	= 4 qt	= 3.7854 L
1 dry pint		= .5506 L
1 bushel (bu)	= 64 dry pt	=35.2390 L

METRIC MEASURES AND EQUIVALENTS

LENGTH

1 millimeter (mm)		= .0394 in
1 centimeter (cm)	= 10 mm	= .3937 in
1 meter (m)	= 1000 mm	= 1.0936 yd
1 kilometer (km)	= 1000 m	= .6214 mi

AREA

1 sq centimeter (cm^2)	= 100 mm^2	= .155 in^2
1 sq meter (m^2)	= 10,000 cm^2	= 1.196 yd^2
1 hectare (ha)	= 10,000 m^2	= 2.4711 acres
1 sq kilometer (km^2)	= 100 ha	= .3861 mi^2

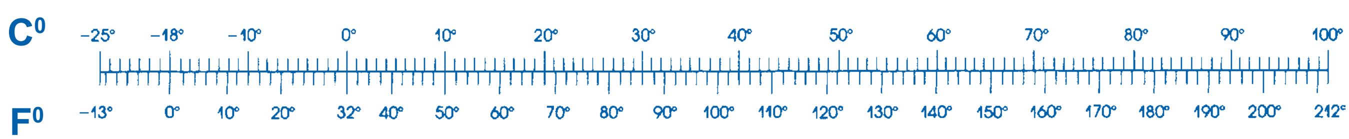
WEIGHT

1 milligram (mg)		= .0154 grain
1 gram (g)	= 1000 mg	= .0353 oz
1 kilogram (kg)	= 1000 g	= 2.2046 lb
1 tonne (t)	= 1000 kg	= 1.1023 short tons
1 tonne		= .9842 long ton

VOLUME

1 cubic centimeter (cm^3)		= .061 in^3
1 cubic decimeter (dm^3)	= 1000 cm^3	= .0353 ft^3
1 cubic meter (m^3)	= 1000 dm^3	= 1.3079 yd^3
1 liter (L)	= 1 dm^3	= .2642 gal
1 hectoliter (hL)	= 100 L	= 2.8378 bu

TEMPERATURE



CELSIUS = $5/9\,(F^0 - 32^0)$

FAHRENHEIT = $9/5\,C^0 + 32^0$

More Useful Information...

ENERGY MEASUREMENT EQUIVALENTS

1 ton	2,000 pounds
1 barrel (oil)	42 gallons, or 5.6 cubic feet
1 watt	A metric unit of electrical power; the product of voltage and current
1,000 watts	1 kilowatt
1,000 kilowatts	1 megawatt
1 kilowatt hour	1000 watts of power used for one hour of time; equals 3,413 Btus
1,000 kilowatt hours	1 megawatt hour
1 quad	one quadrillion Btus
1 MW (megawatt)	1,000 kW (kilowatts)
1 Btu	Quantity of heat required to raise the temperature of one pound of water by one degree Fahrenheit
1,000 Btus	1 kBtu
1 therm	100,000 Btus
1 CCF	1,030,000 Btus
1 gallon	3.785 liters
1 MBTU	1,000,000 Btus
1 ST (Short Ton)	2,000 pounds
1 mcf	.0971 therms

ABBREVIATIONS

bbl	1 barrel (oil)
ccf	100 cubic feet
MW	megawatt
MMbtu	1 million Btus
kw	kilowatt
Btu	British thermal unit
kwh	kilowatt hour
kBtu	1,000 Btus
mcf	1,000 cubic feet
ST	short ton

ENERGY CONVERSION STATISTICS

Carbon dioxide emissions for 1 kWh	1.5 lbs.
Coal required to produce 1 kWh	1 lb.
Average U.S. cost of 1 kWh	8 cents
Average annual gallons of gasoline used per car	500 gallons
Average annual heat savings using 1 low-flow shower head	466 kWh
Average annual water savings using 1 low-flow shower head	14,000 gallons
Average annual savings using 1 faucet aerator	4,000 gallons
Average annual savings using 1 set of toilet dams	5,475 gallons

BTU CONVERSION FACTORS

FUEL TYPE	BTUS
Electricity (Kilowatt Hours) (Site)	3,413
Electricity (Kilowatt Hours) (Source)	11,600
Natural gas (MCF)	1,030,000
Fuel Oil (No. 2) - gallon	138,400
Fuel Oil (No. 6) - gallon	153,600
LPG (liquified propane) - gallon	95,475
Coal (standard short ton)	24,500,000
1 kilowatt hour	11,000
1 barrel of oil	6,250,000